Research on the Walkability Evaluation of Historical Urban Area: Taking Changting, Fujian as an Example

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Abstract. The measure of walking environment is an important indicator to measure humanized city and social ecology, at present, the evaluation of road walkability is still dominated by various strongly subjective built environment indicators, and there is still no quantitative and standardized measure research on the road walkability. Based on the analysis methods of spatial syntax, this paper combines the measured data of vehicle traffic flow, comprehensively evaluates the walkability of urban roads from positive and reverse dimensions, and then proposes optimization suggestions. The research empirically studies Zhaozheng Road which is located in the core protection area of national historical and cultural city, Changting County, Fujian Province; it is an important walking and car path connecting various historic and cultural blocks, the positive and reverse measure of its walkability can also provide new research ideas for the evaluation research of walkability in historic urban areas.

Keywords: *walkability, walking environment evaluation, space syntax, positive and reverse measure*

1. Introduction

The advantages and disadvantages of walking environment will significantly affect walking frequency, time and residents' walking willingness walk. The improvement of walking environment can not only alleviate the urban traffic problems, but also create a green and low-carbon living environment, moreover, it is also conducive for residents to enhance aerobic exercise and improve their healthy level. At the " UN-Habitat III Conference" held in 2017, the creation of an urban space suitable for walking and cycling has become a global consensus, walkability is an important indicator for measuring humanized cities and it is also an important content to embody social ecology. The measure study on walkability has also received more attention.

As an important public space of the city, the roads undertake many functions such as transportation, recreation and life. Therefore, creating a good walking space is an important content of urban road planning, and the measure of road walkability is its basic premise. As the third batch of historical and cultural city in China, Changting County of Fujian Province is gradually promoting the slow working as main traffic mode in its historical city. According to the measured traffic survey data, the internal traffic of historical block of Changting County is mainly walking and two-wheeled vehicles, and Zhaozheng Road is the only important urban road connecting the four core historical blocks and the historical appearance area of Tingzhou Examination Institute, the human traffic and traffic flow at rush hour are both large. So in the historical urban area, most residents and tourists need to pass through Zhaozheng Road to reach other historical blocks, therefore, the walkability of Zhaozheng Road is an important indicator to ensure the walking continuity and pedestrian safety in historical blocks. Through the space syntax perspective, the street walkability can be seen from the street topology itself, and the traffic flow statistics of the actual street reflect obstacle factor of walkability in reality. Therefore, taking Changting Zhaozheng Road as an example, this paper anticipates the ancient city traffic from the perspective of spatial relationship, and analyzes the walkability of a certain road in the positive measure, and investigates the motor vehicles' traffic as the reverse measure, and provides ideas for road walkability evaluation and research.

2. Research Summary

2.1 Research Summary of Walkability

In recent years, academic circles have often tended to expose urban pedestrian space problems through urban fabric graphics[1]. At present, there are many research angles on urban walkability; the superposition of different subjective and objective factors makes the walkability does not have accurate and unified conclusion. Some scholars believe that walkability can be defined as "the friendly degree of built environment for walking [2]". Other scholars have also extended the walkability into "the support degree of urban environment for walking and the evaluation of walker's walking experience in the environment [3]".

The development of related measures and evaluations on walkability in Europe and the United States is relatively mature (as shown in Table.1). Among them, typical representative are: PERS: Pedestrian Environment Review System; NEWS: Neighborhood Environment Walkability Scale; PEQI: Pedestrian Environmental Quality Index; CSR: Community Street Review and so on. And other web evaluation tools such as Walk Score and Walkability Score, Walkonomics' walkability evaluation mobile app walkability APP[4], etc.

Table 1. research history of walkability

category	Year	name	country/region	application range
empirical research	2001	PERS	UK	walking environment
	2002	NEWS	USA	neighborhood district
	2004	ALPHA	Europe	neighborhood residential district
	2004	CSR	New Zealand	street
	2008	PEQI	San Francisco	street
network evaluation	2007	Walk Score	USA	neighborhood residential district
	2011	Walkability APP	Europe	walking environment
	2013	Walkability score	USA	neighborhood residential district

There are scholars in China have studied the walkability construction process of the historical towns of Lubeck, Germany, the research found that on the one hand, Lubeck guides the people from the heart to recognize the central city streets with high walkability have pleasant environment, on the other hand, it provides high-quality "walking+ bike +public transportation" traffic combination mode to replace car travel, thereby reducing car travel [5]. Other existing walkability studies more start with people's subjective feelings for surrounding environment, including road safety, ease of crossing, road quality, road slope, orientation, fun and leisure, etc., all of which the subjective judgment of the street users around the questions set by the researchers. But urban space has growth, especially for ancient cities, the interaction between space and people will promote the continuous change of urban space, thus affecting human behavior. Current studies lack research on evaluation of street walkability from the angle of space and human-land relationship.

2.2 Research Summary of Spatial Syntax

As a spatial analysis technology, spatial syntax was proposed by Professor Hillier[6] in the early 1980s. Space syntax technology has relatively mature research in urban planning and transportation field. At the macro level, scholars use spatial syntax to study the accessibility evolution of urban and rural road networks in urban circles[7], or used in large-scale urban design[8]; at the middle level, traffic network is optimized by constructing spatial syntax mathematical models and conducting rail transit accessibility analysis[9-10]; or construct the relationship between spatial integration indicators and urban commercial layout[11]; or interpret integration, control values, average depth, and intelligibility at the macro level of the ancient city streets, divide block at the middle level and analyze street shape, and close crossing sight at the micro level[12]; or use the spatial syntax axis analyze model and the characteristics of the overall transportation network of the

ancient city, thus providing guidance and support for the protection and renewal of the ancient city [13].

Spatial syntax analyzes two types of configuration modes with the help of topological relations and visibility analysis, including convex space method, axis method and view area analysis method. The axis method is from human behavior, and judges the path selection of people according to sight line, the choice of axis can be regarded as the abstract expression of the space street. This paper mainly uses the axis method to calculate the space syntax.

3. Research Methods and Data Acquisition

3.1 Research Methods

The research technology line is divided into two main lines: positive measure and reverse measure, positive measure is based on the ancient city road data, draws the axis in ArcGIS, uses the Axwoman plug-in to calculate the spatial syntax value, gets control values and connection values to obtain the center of the road, calculate the accessibility of the road by the depth value, then judge the advantages and disadvantages of the spatial structure from the space itself. The reverse measure is to obtain the travel and traffic data of residents through field research, calculates the traffic volume of the car at the crossing of Changting Hotel on the 24th hour of the day in the sunny day, rainy day and holiday three scenarios, and obtain the traffic characteristics of motor vehicle of Zhaozheng Road.

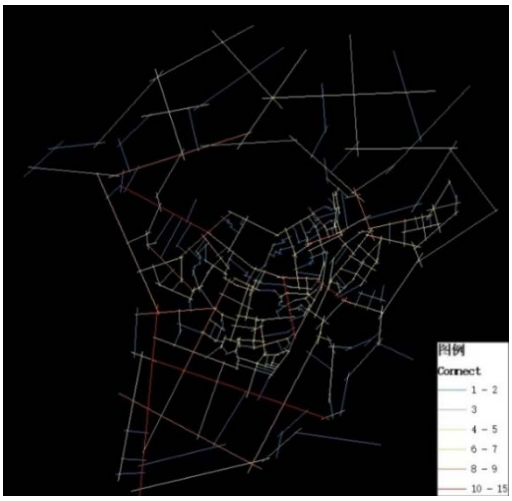
3.2 Data Acquisition

This paper obtains data through field traffic surveys, department visits, and network data downloads: 1: motor vehicle traffic 24 hours in sunny days, rainy days, and holiday different circumstances, Changting Hotel crossing, Zhaozheng Road; 2: shape format data of planning road of "Overall Plan of Changting County (2016-2030)"; 3: download Changting ancient city image map from Google map.

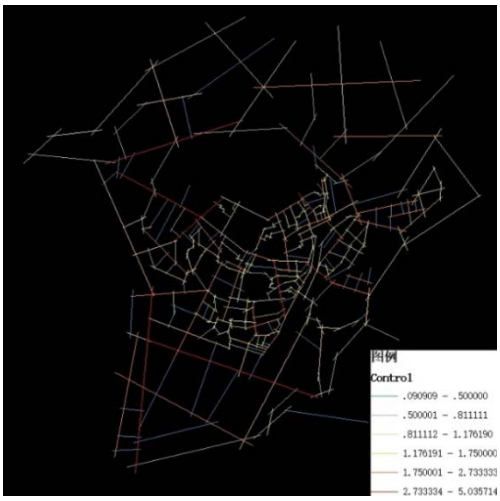
4. Positive Measure Analysis of Spatial Syntax

According to the road traffic data of " Overall Plan of Changting County", the axis is drawn in the geographic information system software ArcGIS10.3 and Axwoman6.3, and the spatial syntax value is calculated. The software will automatically generate the corresponding diagram and calculate the axis connection value, control value, average depth value, global integration degree, local integration degree, global depth value, and local depth value.

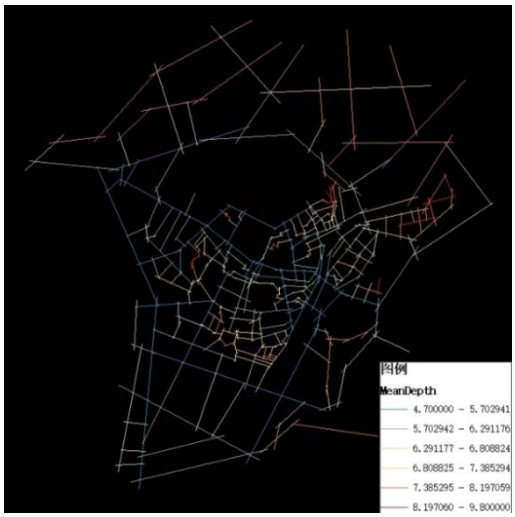
Fig 1 .axis image of Changting ancient city (red axis is Zhaozheng Road).



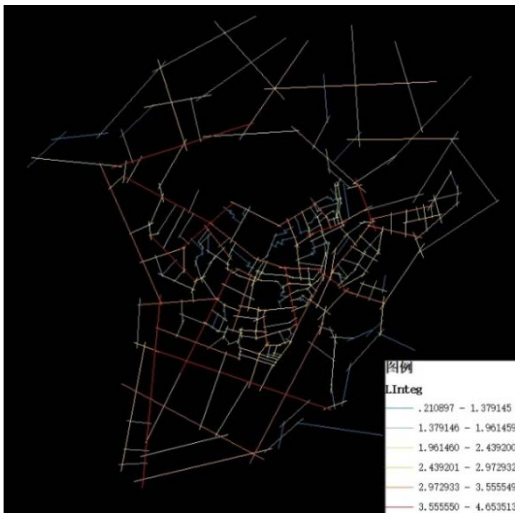
(1) connection value



(2) control value



(3)average depth



(4) local integration

Fig 2. calculation chart of space syntax value.

According to the principle of space syntax, the "longest and least" axis line is drawn; Zhaozheng Road is divided into six axes from west to east, the number is 1-6, the calculation results of each space syntax value confirm the improvement requirements of walkability. (as shown in Table.2, Fig.2).

Both the connection value and the control value confirm the road center of Zhaozheng Road in Changting ancient city; the lower average depth shows that Zhaozheng Road has better accessibility, and the vehicle and the stream of people can be faster; the local integration more reflects that people concentration on the main roads of Zhaozheng Road and its connected core historical blocks is better, and more people will be concentrated to Zhaozheng Road, therefore, the people gathering condition is better and the research needs for walking is larger.

Specifically, in the 6 sections of Zhaozheng Road, the connection value, control value and local integration index of the No.1 and No.5 sections of the historical urban entrance are significantly higher than other sections; it shows that compared with the inner sections of the historical urban area, the roads on entrance sections of both sides of Zhaozheng Road are more accessible, it is easier to attract the entry of traffic flow. However, due to the obvious differences in the reach of the flow of people and traffic, the entrance location of the historical urban entrance with good accessibility is not exactly the same for the flow of people and traffic. Among the indicators of the average depth value, the average depth value of the No.1 and No.5 road sections is higher, it shows that the road grade connected to it is higher, and it is easier to attract the entry of the car. The average depth of sections 3 and 4 located in the historic urban area is lower, it reflects that they are

connected with low-grade roads and are more likely to attract pedestrians and non-motorized vehicles.

Table 2. calculation of space syntax value

number	connection value	control value	average depth	local integration
1	11	4.94	5.00	4.10
2	6	1.43	4.92	3.24
3	7	1.98	4.78	3.42
4	6	0.96	4.70	3.46
5	12	3.46	4.93	4.20
6	6	1.78	5.43	3.07

5. Reverse Measurement Analysis of Motor Vehicle Travel

As an important urban road in Changting ancient city, Zhaozheng Road not only connects the four core blocks and the historical scene of Tingzhou Examination Institute, but also is the main way for motor vehicles. The large amount of motor vehicles will inevitably bring some trouble to pedestrians. According to the analysis results of the above spatial syntax, this paper selects the crossing of Changting Hotel located on the No.1 road section with high traffic accessibility to conduct motor vehicle traffic survey, and analyzes the traffic of Zhaozheng Road in different situations.

In allusion to the traffic of motor vehicles, the 24-hour motor vehicle traffic on the day of working day, the rainy day of working day and the holiday of Changting Hotel crossing on Zhaozheng Road was investigated.

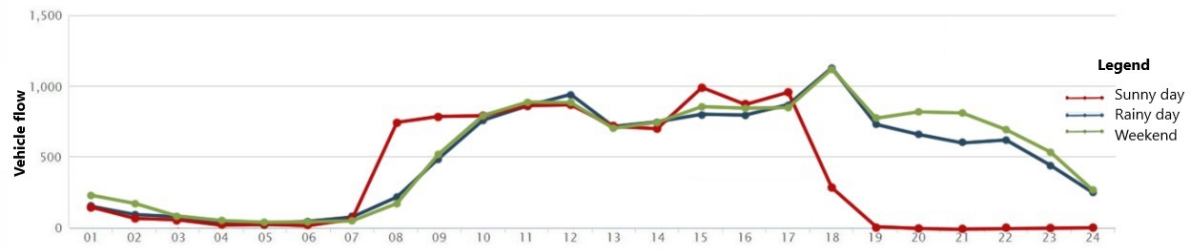


Fig 3. car traffic at the crossing of Changzheng Hotel, Zhaozheng Road.

According to the survey results, the following conclusions can be drawn: (1) people are more willing to choose a car to go to work on a sunny workday, choose other means of transportation to go to work on rainy day on workday or weekends. On the sunny day on workday, the traffic data showed that the morning peak of the study area appeared at 7:00-9:00, while the rainy working day and weekends did not show obvious early peak phenomenon; during the late peak period, traffic peaked on sunny working days about 17:00, and then decreased rapidly. (2)the Car travel situation on rainy working days were similar to that of the weekends, the traffic flow remained at a high level from 9:00 to 23:00, and the traffic on the weekend was slightly larger; (3) during the day (7:00-17:00), the traffic was maintained at a high level (about 900 vehicles), and the road walkability was affected. The peak value was within 1,200 vehicles, of which the peak value of sunny days on working days had reached 982 vehicles at 15:00, and the peak value on rainy working days had reached 1126 vehicles at 18:00, while the weekend was similar to the rainy workday, all reached 1,108 at 18:00. And in the 7:00-17:00 complete cycle, No matter what kind of weather, the traffic on non-working days was relatively large; (4) in the travel mode selection, Motor vehicle travel mainly is by car on rainy working day and weekend, they all reached more than 1,000 vehicles. In a street of Changting County, The harsh environment of rainy day and the rapid pass of motor vehicles had reduced the safety and comfort of pedestrians walking through Zhaozheng Road.

6. Conclusion and Discussion

The street network of Zhaozheng Road is measured from the angle of space syntax, and the positive measure mode evaluation of the space syntactic value of Zhaozheng Road and its surrounding roads is calculated; by selecting the typical road section of Zhaozheng Road, the sunny working day, rainy workday and weekend three typical time scenes, 24-hour traffic flow is observed and counted to carry out the reverse measure of influence of vehicle pass on walkability of Zhaozheng Road. The results show that through the preliminary measure of space syntax on walkability and the positive and reverse measure of vehicle travel in the field, they can reflect the road walkability o to a certain extent, and different road sections have different attraction to motor vehicles and pedestrians. The network structure characteristics of Zhaozheng Road determine high demand for walkability, but the actual walkability is not high, the main reason is that the traffic flow of motor vehicle is large, which affects safety and accessibility of the walking environment, thus affecting the overall walkability. The walkability of the road can be mitigated by traffic design. For example, the road cross sections are reconstructed by means of urban design, and a larger pedestrian area will be reserved; or the outer ring road will be used to divert the motor vehicle to ensure the walkability improvement of Zhaozheng Road.

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